Jet Propulsion Laboratory
California Institute of Technology

Mars Exploration:
Mission Outlook and Technology Needs

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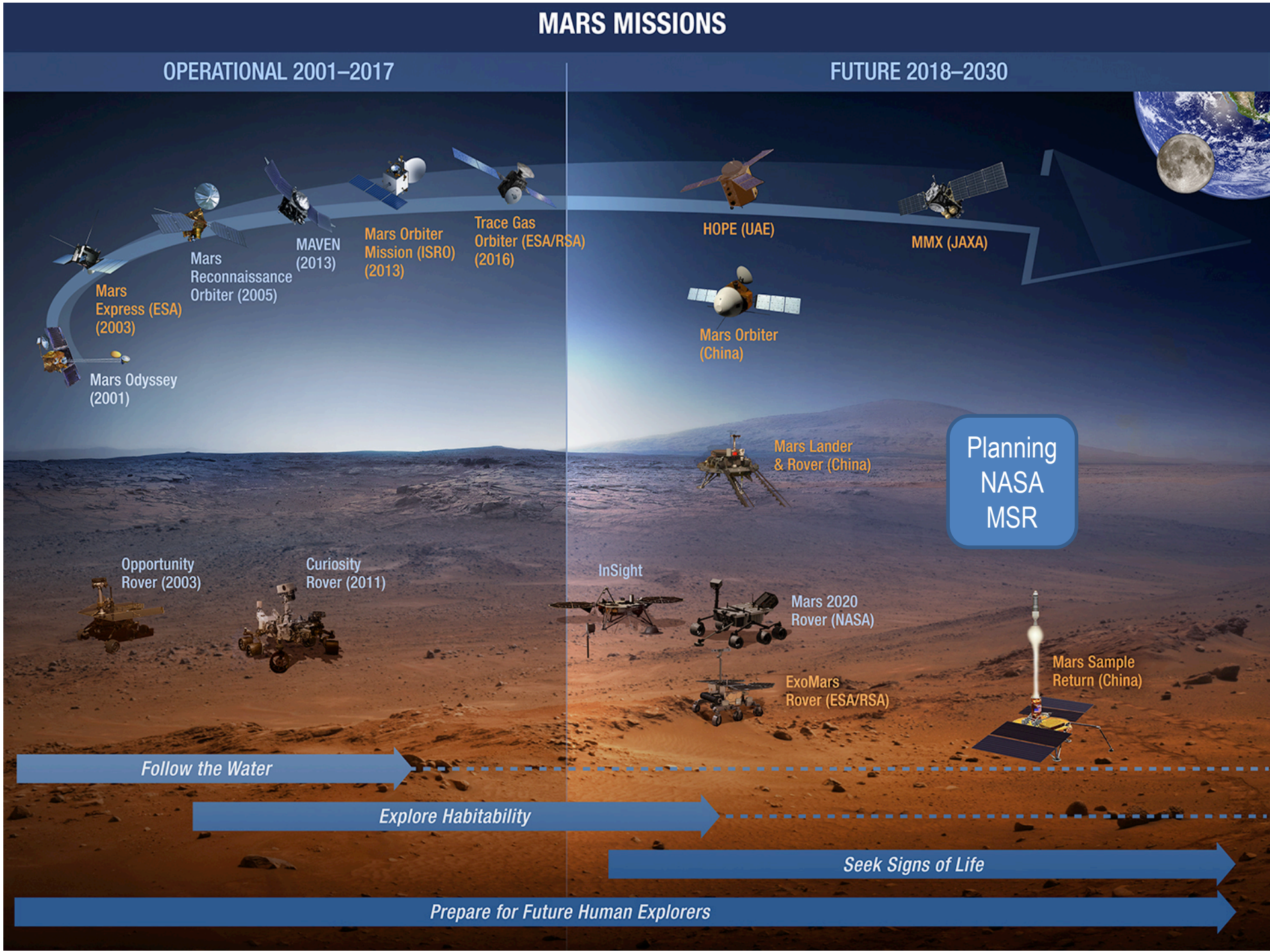
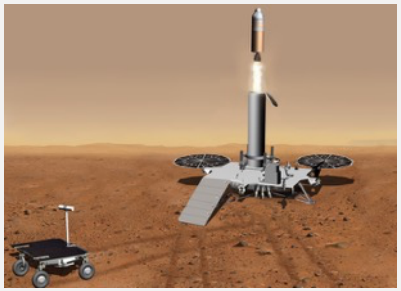

MARS MISSIONS
OPERATIONAL 2001–2017
FUTURE 2018–2030
Mars Express (ESA) (2003)
Mars Odyssey (2001)
Mars Reconnaissance Orbiter (2005)
MAVEN (2013)
Mars Orbiter Mission (ISRO) (2013)
Trace Gas Orbiter (ESA/RSA) (2016)
HOPE (UAE)
MMX (JAXA)
Mars Orbiter (China)
Mars Lander & Rover (China)
Planning NASA MSR
Opportunity Rover (2003)
Curiosity Rover (2011)
InSight
Mars 2020 Rover (NASA)
ExoMars Rover (ESA/RSA)
Mars Sample Return (China)
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Notional Mars Sample Return Architecture

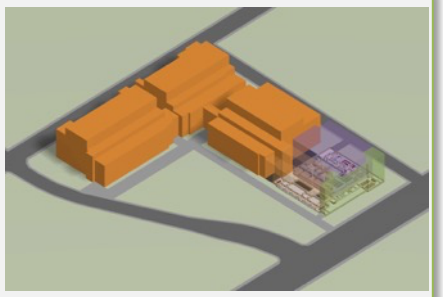
- NASA and ESA are studying a partnership to return samples collected and cached by the Mars 2020 mission
  - NASA would lead a Sample Retrieval Lander mission
  - ESA would lead an Earth Return Orbiter mission
  - Potential launch date as early as 2026, with samples at Earth by 2031

Sample Caching Rover (Mars 2020)
- *Sample acquisition and caching*



Sample Retrieval Lander
- *Fetch Rover*
- *Orbiting Sample container (OS)*
- *Mars Ascent Vehicle*

Earth Return Orbiter
- *Rendezvous and On-Orbit Capture System*
- *Earth Entry Vehicle*

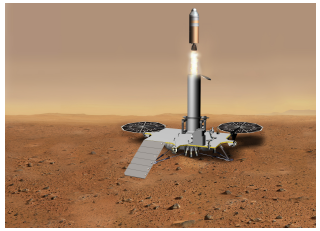


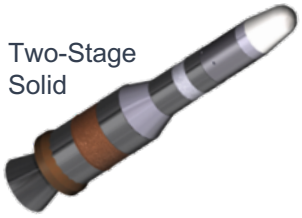
Mars Returned Sample Handling
- *Sample Receiving Facility*
- *Curation*
- *Sample science investigations*

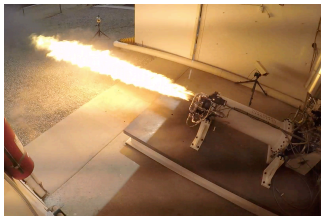
Flight Elements | ***Ground Element***

Mars Technology Needs: Mars Sample Return

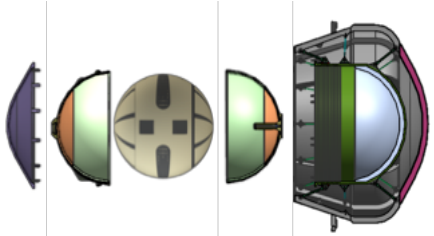
Mars Ascent Vehicle Concept







Containment Assurance

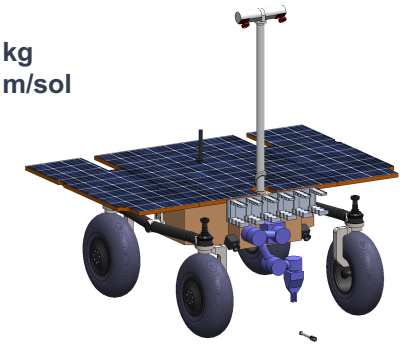


Primary & Secondary Containment

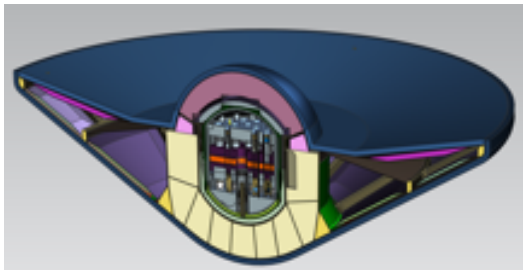
Brazing Test Articles

Sample Fetch Rover

120 kg
200 m/sol



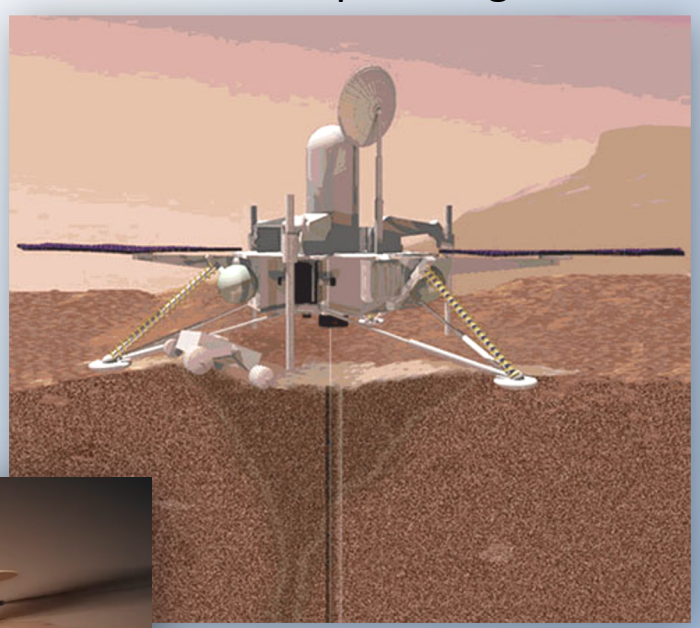
Earth Entry Vehicle



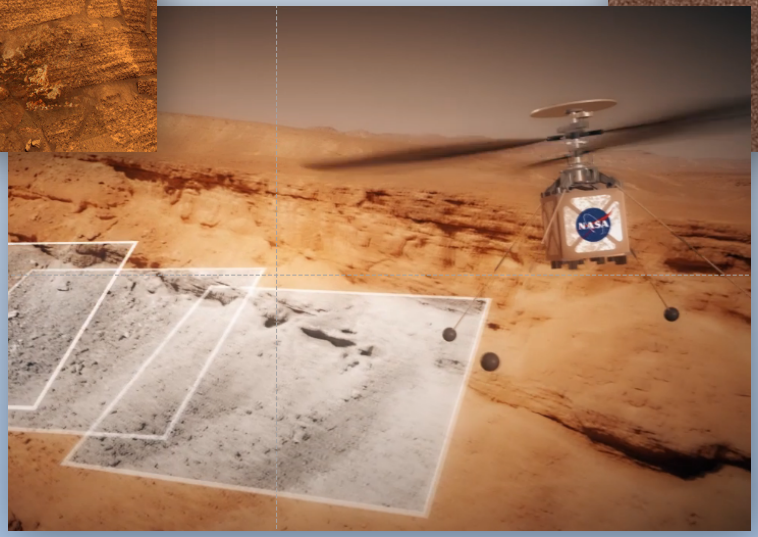
Mars Technology Needs:
New Ways of Accessing Mars

Tethered Rovers

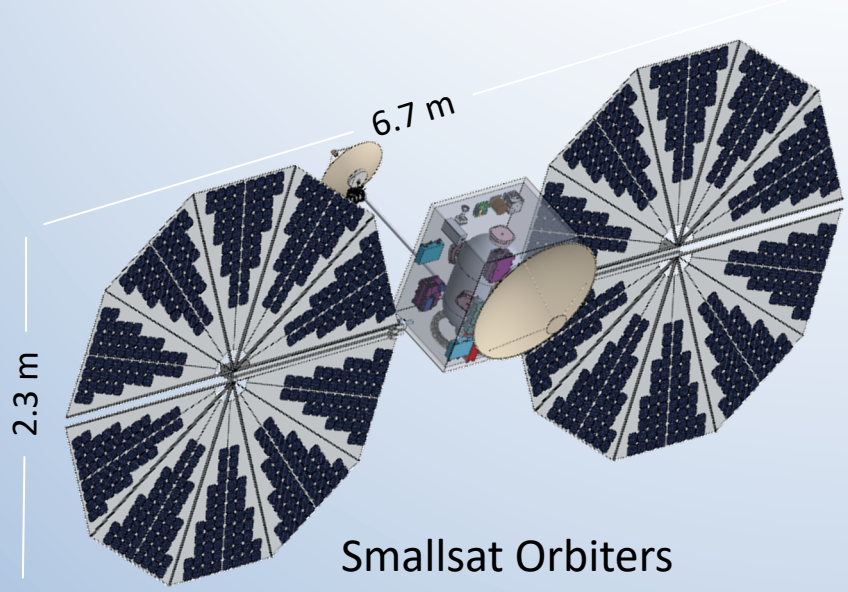
Deep Drilling



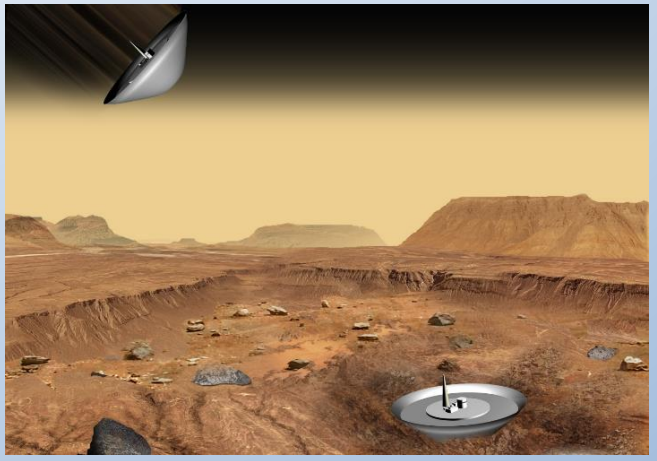
Mars Helicopters



Mars Technology Needs: Low-Cost Mission Concepts

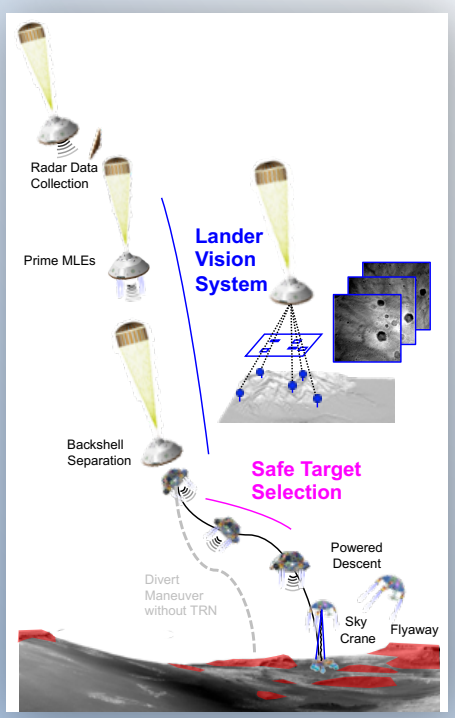


Smallsat Orbiters
~200 kg
SEP Propulsion
Low-cost LVs or GTO Rideshare

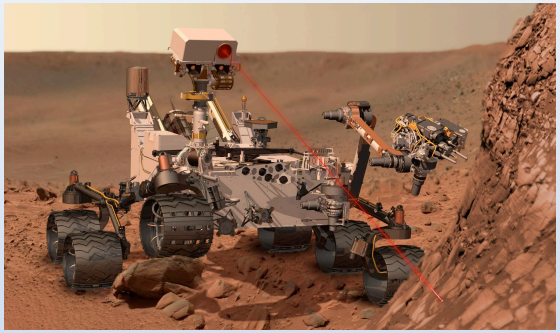


Low-complexity/Low-cost
Hard Landers

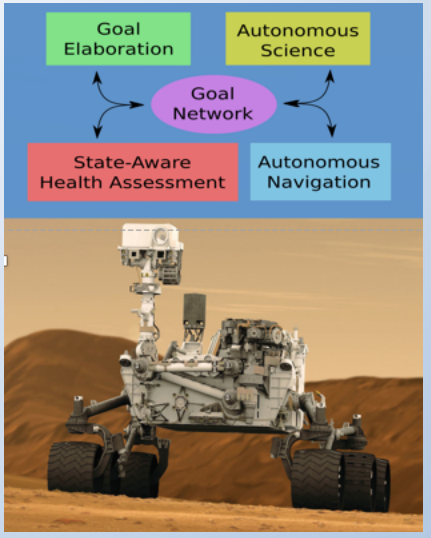
Mars Technology Needs: Increasing Autonomy



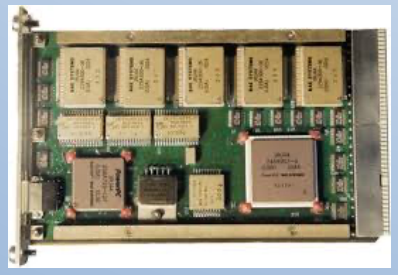
Terrain-Relative Navigation for EDL

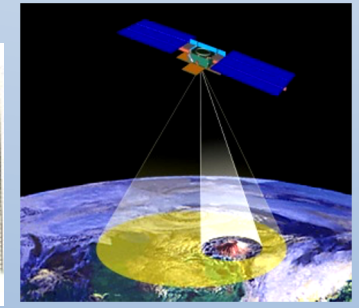


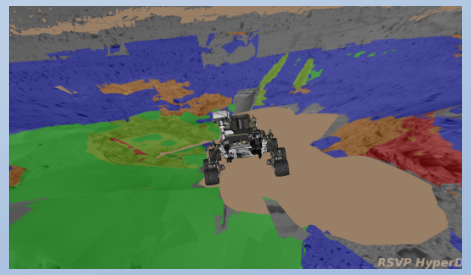
Autonomous Science Target Selection



Self-Reliant Rovers







Onboard Analytics w/ High Performance Spaceflight Computing

Summary

- Continuous robotic presence at Mars since 1997
- Rich mix of orbital and landed missions
- Science-driven, technology-enabled program
- Current focus on sample return planning
- Interest in accessing new regions (extreme terrains, subsurface)
- Exploring opportunities for low-cost, focused science mission concepts

We welcome opportunities to partner with innovators in the commercial sector to identify emerging technologies that can enable new ways to explore Mars